GRAVITY GRADIENT STABILIZATION SYSTEM for the APPLICATIONS TECHNOLOGY SATELLITE

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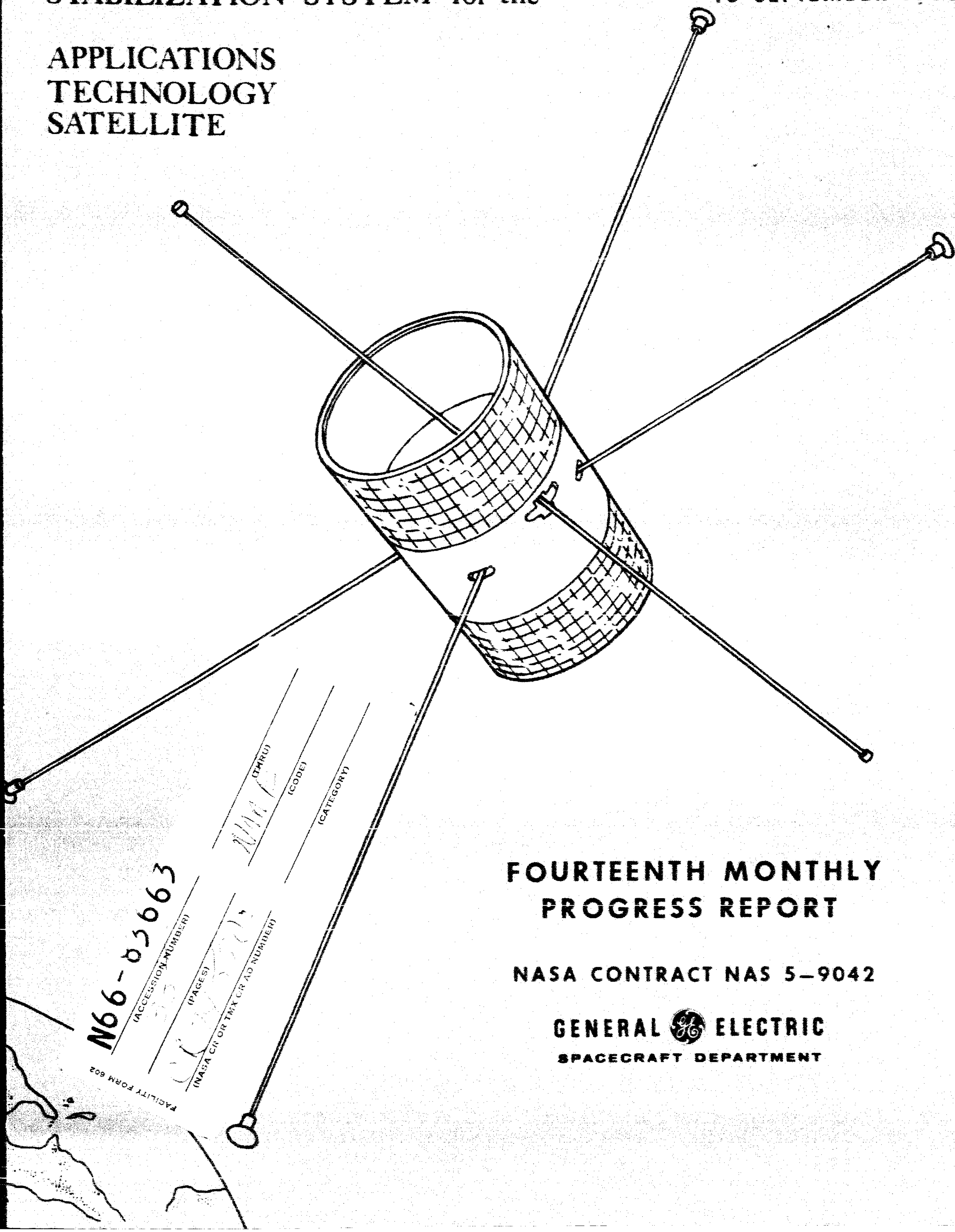
10 SEPTEMBER 1965



FOURTEENTH MONTHLY PROGRESS REPORT

NASA CONTRACT NAS 5–9042

GENERAL ELECTRIC
SPACECRAFT DEPARTMENT

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FOR THE
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FOURTEENTH MONTHLY PROGRESS REPORT

1 AUGUST THROUGH 31 AUGUST 1965

CONTRACT NO. NAS 5-9042

FOR THE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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ATS TECHNICAL OFFICER

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SECTION 1

INTRODUCTION

1.1 PURPOSE

This report documents the progress during the fourteenth month of design and fabrication efforts for the Gravity Gradient Stabilization System of the Applications Technology Satellite. The report covers the period from August 1 through August 31, 1965; however, some reference is made to activities that occurred during July which were not completely documented in the shorter letter report submitted on August 10th.

1.2 SCOPE

Under Contract NAS 5-9042, the Spacecraft Department of the General Electric Company has contracted to provide Gravity Gradient Stabilization Systems for three Applications Technology Satellites: one to be orbited at 6000 nautical miles and two which will be orbited at synchronous altitude. The gravity gradient stabilization system will consist of primary booms, damper, attitude sensors, and a power control unit. Two sets of aerospace ground equipment will also be furnished to enable ground checkout of the gravity gradient stabilization systems.

1.3 PROGRESS SUMMARY

The GGSS thermal units were prepared and delivered to NASA in accordance with the contract schedule. These units will be used in an ATS thermal test of the total system to be conducted by the vehicle contractor. A discussion of the thermal units is presented in Section 11 together with photographs taken at GE prior to delivery.

Fabrication and evaluation of the GGSS Dynamic Models was in process during August. It is anticipated that these units will be ready for NASA acceptance in accordance with the contract schedule.

SECTION 2

SYSTEMS ANALYSIS AND INTEGRATION

2.1 ATS MATHEMATICAL MODEL

The engineering analysis for the ATS Mathematical Model is essentially complete. Final documentation and publication in finished form will require approximately two months. Programming and de-bugging continue with anticipated completion by the end of this calendar year. The emphasis in engineering analysis is currently shifting to analytical justification of assumptions.

2.2 ATS-A CAPTURE ANALYSIS

The upright capture experiment on ATS-A (this experiment is not required but is desirable) as opposed to total capture has been jeopardized due to upward revisions in initial (prior to boom deployment) moments of inertia estimates. The pitch moment is better than 30% higher than that utilized for the study reported in the Fourth Quarterly Progress Report. A final evaluation (prior to completion of the ATS Math Model) is in progress using the GAPS-IV computer program. Moment of inertia values to be used for this final study are shown in Table 2-1 and represent best available data as of 11 August 1965. (J. Lotta, Hughes Aircraft Company).

Table 2-1. Moment of Inertia Data

Spacecraft	Inertial Axis	Moment (slug-ft^2)
A	x (yaw)	51.99
	y (roll)	56.86
	z (pitch)	65.51
D/E	x (yaw)	54.70
	y (roll)	51.37
	z (pitch)	62.43

Boom extension rates to be utilized cover the range 0.90 ft/sec to 1.50 ft/sec and represent the range permitted by the current boom system specification. Preliminary results indicate (for 3-sigma initial rate conditions) that upright capture is not achieved at any of the allowable boom extension rates. Capture in either of the bistable modes is not in question.

2.3 ATS-D/E CAPTURE ANALYSIS

Capture studies on ATS-D/E are concentrated primarily on determining the effects of initial spin axis orientation (and residual rate after dispin) on tumbling time. Preliminary results indicate a significant sensitivity to initial spin axis orientation. If spin axis orientation (prior to despin) is permitted to be randomly orientated and tumbling times exceeding 600 hours considered unacceptable, the residual spin rate (after yo-yo despin) should not exceed approximately 1.0 deg/sec. However, if the spin axis is held or processed (prior to despin) to an orientation parallel to, and with the same sense, as the orbit's angular momentum vector, the constraint on residual spin rate can be relaxed to 2 deg/sec. (A residual rate of 1 deg/sec produces no tumble; 2 deg/sec tumbles for 45 hours; 3 deg/sec tumbles for greater than 600 hours.

2.4 LAUNCH CONSTRAINTS

Section 2.4.1, Launch Constraints, of GE's Fourth Quarterly Progress Report, contains an erroneous presentation in the first of 3 curves shown in Figure 2-2. "Months of $\delta' \leq 25^{\circ}$" should not be constant past June 14 as shown; rather it should decline linearly to about 15-1/2 months at the end of September and then hold relatively constant at that value until the end of the presentation. The two periods of initially continuous sunlight, then, correspond to periods exceeding 15 months for $\delta' \leq 25$ degrees. It should also be pointed out that launch between 27 March, 1967 and 14 June, 1967 eliminates the possibility of a continuous sunlight region at any time during the first year and the GE constraint cannot be satisfied even in the alternative manner discussed.

2.5 ATTITUDE DETERMINATION PROGRAM

The final sensor system engineering analysis report ("Satellite Attitude Determination Via Radar Polarization Angle and Solar Aspect Sensor Measurements") has been documented and published. As reported in the Fourth Quarterly Progress Report, emphasis has shifted to more extensive use of the computer as a design tool. The engineering analysis for both the Simulation Program and the Data Processing Investigation Program has been completed. Both are currently being programmed. The orbit module (per agreement at the 19 July 1965 working session with NASA) will be that described by G. D. Repass and R. G. Chaplick in "A Mutual Visibility Computer Program for Communication Satellites," NASA/GSFC, X-547-65-222, May 1965. A copy of this report was received 9 August 1965 and is under study for incorporation into the Attitude Determination Program.

2.6 TEST REQUIREMENTS AND PERFORMANCE

Drawings of the aerospace ground equipment for the GGSS were 90% completed at the end of the month, and the manufacture of the AGE parts was 50% complete. Based on present progress in this area, AGE will be available at the required time for system tests.

GE's comments to the NASA Specification S2-0105, "ATS Spacecraft Expected Environment" were submitted to NASA in the General Electric internal document PIR 4730-130 during the week of July 18th. Of particular significance were the comments on the proposed radiation environment. The following conclusions were reached in the PIR for radiation considerations at synchronous and medium altitudes.

1. For the synchronous case, the environments are essentially the same. The factor of two reduction in the solar flares does not significantly change the accumulated dosage. The solar flare specification still appears to contain a fair degree of conservatism. For example, the solar flare specification for a near-earth environment presently being used for the Voyager study is about an order of magnitude lower than the subject

specification. The Voyager flare environment was in agreement with the JPL-Voyager specification; i.e., if it were a factor of ten less than presently specified, the corresponding ionization doses would be on the order of 10^4 rads for three years. This value would make the presently allowed 20% reduction in gain, as specified in GE Specification SVS-7328, somewhat more realistic.

2. For the medium altitude case, the omission of the solar flare specification reduces the problem essentially to an insignificant level. However, the omission of a solar flare environment for the medium altitude does not seem reasonable.

Dipole tests were conducted on the TRW, Inc., hysteresis damper, the Power Control Unit relays and transistors, and the damper clutch solenoid. All tests were made with the components in the non-operating condition, and none exceeded a magnetic dipole of 15 pole centimeters. Plans call for dipole tests on all engineering hardware during the initial and final functional tests.

Sketches were completed for the construction of a mockup of the ATS vehicle. The mock-up will be used by GE during system evaluation and functional tests of the GGSS. All components will be installed on the mockup and tested functionally with the AGE before they are shipped to HAC.

Work is progressing on schedule for modifications of the chamber which will be used for solar vacuum evaluation tests; 60% of the work has been completed.

Micrometeoroid testing was completed on two beryllium-copper rod specimens; one of the specimens was silver plated and the other was not. Damage of the specimens precluded thermal radiative measurements. Calculations of the particle flux indicated an equivalent of approximately one-year orbit exposure. Efforts will be directed to conducting similar tests in which thermal radiative properties can be determined.

A schedule was completed for a series of integrated engineering evaluation tests of the GGSS components. The schedule indicates that all tests will be completed in 1965.

The present schedule for the system evaluation tests at GE calls for testing to be started during the week of October 18th. Completion is scheduled for the week of November 22nd. These tests will be conducted with the use of the mockup of the HAC structure.

SECTION 3
BOOM SUBSYSTEM

In order to eliminate a major technical problem area of the boom system it was necessary to redesign the damper boom release mechanism. Effort early in the month centered around salvaging the Conax bolt cutter design while preliminary studies of possible backup designs were underway. However, failure analysis carried out by the vendor (Conax) as well as GE and deHavilland have led to the conclusion that very extensive testing would be required to assure the adequacy of any modification to this concept. Accordingly, the primary emphasis has been shifted to an alternate scheme based on an already qualified pyrotechnique device. Two such backup designs are presently being investigated. Both use a pre-qualified, high shear release nut as a prime mover. The first device employs a simple clevis-type, tie-bar which is separated when the explosive device drives the engaging keys from the keyways of the clevis. The second device, which is expected to require smaller release loads of the of the explosive nut, employs a commercially available pip-pin type release mechanism. DeHavilland has manufactured a test model of the first device and development tests will proceed as soon as the squibs, which have been ordered for this device, are on hand. GE has initiated procurement for the release mechanism of the second device.

Retrofit of Engineering Model T-1a to incorporate the release re-design will be implemented on a crash basis.

Thermal and Dynamic units of the boom system were received at GE on August 3rd.

The thermal models were retrofitted at GE to incorporate the resistors associated with the 21.2 volts to be used in the ATS system thermal test. The thermocouplers were installed and the thermal units were checked out and are now ready for delivery to NASA/GSFC.

The Damper Boom of Engineering unit T-1a was received at GE on August 29th. Due to the development problems with the release mechanism, this unit was conditionally accepted with a manually activated release mechanism. This unit will be subsequently retrofitted to incorporate the re-design release.

Delivery of the Primary Boom Package to GE continues to slip due to assembly and test problems at deHavilland. Damage to the unit due to improper activation by the test operator is the most recently reported reason for the slippage.

A strike at deHavilland began Tuesday, 24 August. This was approximately three days ahead of the anticipated strike schedule. Work is continuing at deHavilland utilizing engineering technicians, engineers and supervisory personnel. Action has been taken by GE Contracts personnel to involve the Canadian Government's support towards the end of insuring no unnecessary schedule dilution. NASA has been contacted to aid in the problem. There has been no attempt by the strikers to lock out supervisory and engineering personnel. GE Vendor Surveillance personnel are at deHavilland on a full-time basis. DeHavilland is attempting to subcontract portions of their work and administrative functions such as the preparation of financial reports. In the event that the strike situation worsens, deHavilland is prepared to bring their hardware and small special tools to GE to continue their development work here.

SECTION 4
COMBINATION PASSIVE DAMPER

4.1 SUMMARY

Major events which have occurred since the last report period include:

1. All work on the variable torque (bow-tie) disc for the hysteresis damper was discontinued on 7 July. (This item was inadvertently omitted from the last report.)

2. Tests on the solenoid on 30 July proved conclusively that a caging device for the solenoid is required.

3. Final assembly drawing for the CPD was officially released on 2 August, and the Dynamic Unit Assembly drawing was released 5 August.

4. TRW Systems shipped Engineering Unit No. 2 of the PHD on 3 August.

5. Fabrication of the CPD Thermal Unit was completed on 10 August; however, resistor (heaters) values were changed and actual delivery was delayed until new resistors could be obtained and installed.

6. All CPD test plans and equipment are proceeding on schedule and will be available for CPD Engineering Unit No. 1 testing.

4.2 DESIGN DEVELOPMENT EFFORTS

4.2.1 CONFIGURATION STATUS

All drawings for the manufacture of parts in the CPD have been released, and the final assembly drawing (GE Dwg. PR47E207100) was released on August 2nd. A procedure was initiated for making the adjustments that will be required during assembly (GE Dwg. 47A207483). The drawing for the CPD handling fixture (GE Dwg. 47E207487) was issued on August 18th; this fixture will be used for handling the CPD during tests and assembly into the spacecraft. Changes, which have resulted from experienced gained during the manufacturing cycle of the Thermal and Dynamic Models of the CPD, will be incorporated into the drawings for the Engineering Unit. The latest changes to the CPD package were incorporated into the envelope drawing (GE Dwg. 47D207098) and a second sheet was added which delineates the pins on the electrical connector.

4.2.2 DYNAMIC MODEL

All manufacturing information for the Dynamic Model (GE Dwg. 47E207390) has been released, and the final assembly drawing was issued. The procedure was issued which details the adjustments required during assembly of the Dynamic Model. The interface drawing (designed to be used by Hughes Aircraft) was prepared. Plans have been completed for the in-house tests that will be made by GE on the CPD Dynamic Model before the unit is shipped.

4.2.3 THERMAL MODEL

Manufacture and assembly of the CPD Thermal Model were completed. This unit, shown in Section 11, was subjected to temperature cycling, in order to confirm the quality of the thermal coatings, and to check the performance of the heater and thermocouple circuits. The Thermal Model Interface Drawing (GE 47C207493) was issued. As of August 31, the unit was ready for shipment to NASA/GSFC at Hughes Aircraft.

4.2.4 ANGLE INDICATOR

Drawings for all parts of the angle indicator have been finished and parts are either completed or are being fabricated. The fiber optic assembly is being reworked by the vendor due to the lack of proper scrambling of the fibers. This is the last remaining purchased part to be reviewed. The lamps were subjected to the vibration test schedule that is described in the CPD specification (SVS-7314) with no failures. Also shock tests were made with the lamps lighted and no failures occurred. Testing is now in process to determine the amount of energy available from the lamps and to the phototransistors. Actual hardware is being used where possible to avoid any errors due to simulation and subject extrapolation of results.

4.2.5 TORSIONAL RESTRAINT TESTS

Investigation of materials for the Eddy Current damper torsional restraint has continued. To date laboratory samples of magnetic powder dispersions in epoxy resin appear to be the most promising. The main difficulty to be overcome is non-linearity. If this cannot be readily overcome a second look at magnetic tapes will be initiated.

Electrolytic iron powder dispersions offer a factor of four reductions in hysteresis and appear to meet all other requirements. Carbonyl iron powder appears to have almost negligible hysteresis but in addition to difficulties with non-linearity, this material has relatively strong lateral force characteristics which may rule out the use of this material. Work will continue in this area during the coming reporting period.

4.2.6 BOW-TIE DEVELOPMENT

In the Fourth Quarterly Report, a brief discussion was included on the development of a hysteresis damper element which had a damping characteristic that more closely approached the optimum damping times of the spacecraft. On July 7, the development effort on this element was discontinued.

4.3 SUBCONTRACT ACTIVITY

4.3.1 PASSIVE HYSTERESIS DAMPER

Prototype No. 1 (ATS-A Configuration) has been assembled at TRW and testing has begun. Development model vibration tests of the ATS-A Configuration indicated an adequate design. The suspension wires were intact after the unit was subjected to more than ten qualification level, or greater, tests in the thrust axis direction.

The functional performance was checked before and after each of the vibration tests and no changes in performance was noted.

4.3.2 DAMPER CLUTCH SOLENOID

The Engineering Unit No. 1 solenoid was repaired after the uncaged vibration test failure. The failure resulted in loosening of the pole pieces, although the solenoid still functions satisfactorily. The unit will now be retested prior to installation into Engineering Unit No. 1 of the CPD.

The force versus travel curve of the solenoid is presently shaped to conform to the curve of the cone diaphragm force versus travel characteristic. Test data indicate that the solenoid force is at least 25% higher than required under the worse extremes of temperature and solenoid input voltage.

4.4 TEST EQUIPMENT

4.4.1 LOFF FIXTURES

Fixtures for holding the CPD have been designed and fabrication is approximately 50% complete.

4.4.2 ADTF FIXTURES

Fixtures for holding the CPD and hysteresis damper have been designed and fabrication is about 60% complete.

4.4.3 TEST CONSOLE

CPD Test Console No. 1 is completely assembled and 90% checked out. Test Console No. 2 is 50% complete. The harness to be used for the various CPD tests is 3% complete.

SECTION 5

ATTITUDE SENSOR SUBSYSTEM

5.1 TV CAMERA

Interface drawings for the camera (GE Dwg 47D207484) and the control unit (GE Dwg 47D207485) were released during the week of August 22nd, and copies were delivered to NASA/GSFC. The camera interface drawing includes the mounting bracket design that incorporates the concept proposed by NASA, and the dimensions for the mating connector. The camera subcontractor will be directed to implement these changes pending the results of a quote for their additional effort. The Fourteenth Monthly Interface Report for August will include copies of the new camera and control unit interface information.

Plans were published in the GE internal document (PIR 4176-441, dated July 20, 1965) for the engineering evaluation tests and procedures of the TV camera system. This evaluation will be made on one engineering model prior to qualification testing. The range of testing will include:

1. Visual and Mechanical Inspection
2. Temperature Tests
3. Corona Tests
4. Solar Vacuum Tests
5. Aperture Stop Tests

Functional performance tests will be conducted before, during and after these tests to determine whether changes take place in excess of the tolerances permitted by the component specification, SVS-7310.

Discussions were held with Lear-Siegler relative to the need for specialized optical equipment for measuring camera resolution during environmental stress. Plans were approved to test the camera with the test chart constructed by GE. The chart will be 5 feet wide by 7 feet high and incorporate patterns for evaluating field of view, horizontal and vertical resolution at the corners, and determination of linearity. The chart also incorporates a target scale for the probable location of the TV targets on the ends of the primary boom system. This chart is presently proposed for use in the engineering evaluation tests and the subsequent qualification tests. It is planned to use a second test chart with a standard 18-inch by 24-inch, RETMA resolution pattern for testing the camera while it is in the thermal-vacuum chamber.

The thermal model of the camera and control unit were reworked to include the addition of appropriate power resistors to accommodate an input of 21.2 volts during ATS system thermal tests at HAC. The dynamic models of the camera (with dummy optics) and the control unit were received from the subcontractor during the week of August 23rd. The weight and centers of gravity of both units agreed with specification requirements.

Operation of two TV monitors (furnished by NASA) was checked in a GE closed circuit industrial TV system. Both monitors exhibited some shading and foldover at the top of the picture, as they previously had shown on the Model 0431B camera that was borrowed from Lear-Siegler. The foldover may be caused by the lack of equalizing pulses in the sync format from the GE camera; this will be checked. However, since the Lear-Siegler Model 0431F Cameras will not have equalizing pulses, better quality TV monitors may be required.

5.2 SOLAR ASPECT SENSOR

Development testing of the engineering unit at the Adcole Corporation was completed and the unit delivered to General Electric. The room ambient functional tests performed thus far at GE show good agreement with similar data taken at Adcole. These tests have consisted of tests of the electronics unit using simulated current inputs, and tests of the SAS detector under simulated solar illumination to determine the accuracy of each bit transition. Future tests will ascertain the performance of the system with compound error angles, and under the influence of the various specified ATS environments. Quality control personnel are following the tests to become familiar with the component and test equipment to ensure that later qualification and acceptance tests run smoothly.

Major problems are not expected in the thermal environment since Adcole successfully operated the component at -55°C and at 85°C.

General Electric test equipment has been thoroughly checked out. The component test panel has been debugged and is working properly. The solar simulator intensity distribution was mapped and found to be less uniform than expected. The non-uniform distribution will prevent testing of more than one reticle at a time and will make compound angle testing more difficult.

5.3 POWER CONTROL UNIT

Assembly was completed of the six printed circuit boards for use in the engineering unit of the PCU. Each board underwent an electrical test prior to interconnection with the other boards. It was discovered that several pin connectors were too close to potted modules. These connectors will be separated on subsequent models.

An additional No. 20 wire was added to the internal harness to double the current carrying capacity of the CPD solenoid driver circuit (damper clutch solenoid).

The test procedure for the engineering unit was performed on the test rack with the use of the breadboard of the PCU in order to verify the procedure and obtain data for later comparison.

Production drawings were revised and updated during the month to enable corrections of the prototype unit.

SECTION 6

MANUFACTURING

Support was provided by Manufacturing to retrofit the GGSS Thermal Units with the recommended heat dissipating resistors. Additional assistance was furnished in preparing the units for inspection and acceptance by NASA/GSFC.

The Dynamic Models of the Combination Passive Damper and the Power Control Unit were fabricated at GE. Metal weights were added to the PCU to simulate the specified weight and c.g. location. Foam was added to the unit to insure that these weights would not shift position under the anticipated dynamic environments.

The wiring boards of Engineering Unit No. 1 of the PCU were fabricated and tested during the reporting period. This effort included the manufacture of seven printed boards and 23 modules. The unit was then delivered for engineering testing. Manufacturing will continue to provide support as required during these engineering tests.

SECTION 7

QUALITY CONTROL

7.1 THERMAL MODEL TESTS

Evaluation of the thermal models was performed at GE to the test requirements prepared by Quality Control. Each of the units was exposed to one temperature cycle (of the applicable specification). The power dissipation of all units was checked using the HAC system applied voltages obtained from the thermal test requirements. A pin-to-pin continuity check was performed, followed by a resistance check of all thermocouples.

The thermal units were exposed to a 24-hour bake at a temperature of $150^{\circ}F$ in a vacuum of 10^{-5} mm Hg to ensure that the components were outgassed before shipment. (See Section 11 for more thermal unit details.)

7.2 TEST FACILITIES

The solar aspect sensor test facility was put into operating condition during the week of August 9th and the facility was checked out and aligned.

SECTION 8

RELIABILITY AND PARTS AND STANDARDS

8.1 RELIABILITY

8.1.1 POWER CONTROL UNIT ANALYSIS

A detailed part-by-part analysis was conducted on the Power Control Unit circuitry. Each potential piece-part failure mode was examined for the effect a failure would have on the interrelationship of the module, PCU and system performance. The probability of occurrence of a particular module failure mode was considered as the sum of the probabilities of all the piece-part failure modes that could lead to the outcome. In computing the failure modes, a duty cycles of a three-year mission operating time was assumed for telemetry and power switching functions, squib drivers were based on a duty cycle of 100 hours, and gravity gradient experiments, such as boom maneuvers, were based on a mission life of 200 days. Failure rates employed in the analysis were based on a study of the Hi-Rel part rates from several other programs including Minuteman, MACS and Advent.

The detailed findings of the PCU Reliability Analysis were documented in the GE internal report, PIR 4144-237, dated July 17, 1965; copies have been sent to NASA/GSFC.

8.1.2 PRIMARY BOOM ASSEMBLY WIRING

DeHavilland has proposed redundant wiring for most primary mission functions, utilizing presently unused pins on the connector. It was recommended that this modification not be adopted. The theoretical gain in reliability obtained through redundancy is realized only if the redundant elements have independent failure rates; this is not the case when functional conducting paths are duplicated in a single harness connector. Secondly, incorporation of the change would involve a 35% increase in the number of harness conductors required for mating the boom assembly with the PCU.

DeHavilland has also proposed a change in the extension and scissoring motor limit switch wiring from a two-switch, series arrangement in each armature and field circuit to a single, series-parallel circuit for each motor. In the present configuration, failure to "make" in any of the four switches would result in loss of extension capability. DeHavilland's modification would reduce this hazard to a negligible level. Therefore, it was recommended that this change be incorporated into the primary boom assembly.

8.2 PARTS AND STANDARDS

8.2.1 COMPUTER PROGRAM

The computer program for analyzing data from the vendor's screening tests has been completed. It was checked by using existing data from earlier parts testing programs. The program consists of calculation of average, standard deviation and skewness for four parameters at four time intervals for fifty parts, arranging each set in order of magnitude, calculating a trend factor based on the parameter changes between the first two and last two time periods, calculating average, standard deviation and skewness and arranging in order of magnitude. A total of 1.2 minutes of 7094 computer time was required for this calculation.

8.2.2 SAS PARTS LISTS

The parts lists submitted by Adcole Corporation for the Solar Aspect Sensor were reviewed in detail. In general, it was noted that most parts listed are approved parts and are properly documented. Recommendations were made to bring the parts lists into full conformance with the Approved Parts List 490L106, and to align material selections to the Approved Materials and Processes List 490L107. Such detailed analyses will be contined on other components.

8.2.3 PARTS DRAWINGS

New drawings released for the program during the reporting period were:

R4615	Semiconductor, Phototransistor, Silicon, NPN
R2206	Connector, Plug, Electrical Bayonet Coupling, Solder type Contacts (for Potting)
47C207314	Lamp, Double Filament Angle Indicator

Revised and updated drawings include:

R4523, Rev. B	Composition Resistor, 1/4 Watt
R4524, Rev. A	Composition Resistor, 1 Watt
R4530, Rev. A	Film, Deposited Carbon Resistor, 1/4 Watt
R4545, Rev. A	Semiconductor Diode
R4549, Rev. A	Semiconductor Diode
R4583, Rev. A	Semiconductor Transistor
R4604, Rev. A	Semiconductor Transistor
R4612, Rev. A	Two-Way Solenoid

HAC 988705, Rev. D
HAC 988705 Addendum, Rev. B
HAC 988716, Rev. D
HAC 988853, Rev. D

SECTION 9

SPECIFICATION STATUS

The following lists the number and title for each component specification associated with the ATS Gravity Gradient Stabilization System. The Space Vehicle Specification (SVS) number designates the particular document which is recorded and controlled within the GE Spacecraft Department.

Specification No.	Title	Status
SVS-7306	Solar Aspect Sensor-ATS	Revision B - 1/4/65
SVS-7307	Power Control Unit-ATS	Review (Awaiting Comments)
SVS-7310	TV Camera Subsystem-ATS	Revision D - 7/16/65
SVS-7314	Combination Passive Damper	6/4/65
SVS-7316	Boom Subsystem	Revision C - 4/28/65
SVS-7325	Standard Parts, Materials and Processes, Use of	Revision C - 1/4/65
SVS-7331	Passive Hysteresis Damper	3/8/65
SVS-7338	Standards, Engineering Equipments	Revision B - 4/15/65

SECTION 10

PROGRAM SCHEDULE

The schedule for the hardware items which will be delivered for use by the spacecraft contractor is shown in Table 10-1. The schedule is a summary of the detailed PERT networks which have been established and will be maintained for program control. The schedule is based on the revised program defined in the Work Statement, GE Document 65SD4293 dated April 20, 1965.

TABLE 10-1. DELIVERY SCHEDULE FOR GRAVITY GRADIENT STABILIZATION SYSTEMS

	1965												1966											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Thermal Model									▲															
Dynamic Model									▲															
Prototype Unit																△								
Flight Unit No. 1 (ATS-A)																					△			
Flight Unit No. 2 (ATS-D)																						△	*	
Flight Unit No. 3 (ATS-E)																							△	**

△ Estimated Delivery Date
▲ Actual Delivery
* To Be Retained By G.E. Until Sept. 1, 1967
** To Be Retained By G.E. Until Mar. 1, 1968

SECTION 11

HARDWARE DELIVERY

The GGSS thermal models were prepared for acceptance by NASA during August. These components are intended for use by the Hughes Aircraft Company in a system thermal test. The hardware consists of:

1. Combination Passive Damper and Damper Boom (Figure 11-1)

2. Primary Boom Package (Figure 11-2)

3. TV Camera with Lens and Camera Control Unit (Figure 11-3)

4. Solar Aspect Sensor Electronics Unit and Five Sun Sensor Detectors (Figure 11-4)

5. Power Control Unit (Figure 11-5).

Each thermal model has been fabricated to dissipate the same nominal power to within 10% of the predicted flight units when an input of 21.2 volts is applied. Several power dissipating resistors have been mounted in most of the units to distribute the power dissipation within each unit. In addition, the primary boom package contains separate resistors for the "extension" and "scissor" motors to allow them to be energized separately. Resistors have been selected which are capable of dissipating twice the predicted nominal power. Thermocouples of No. 30 copper-constantan wire with 50-foot-long leads have been used on all components.

Aluminum has been used freely in the thermal models to replace the mass of transformers, motors, magnets and other mass contributing components and, in some cases, to replace more exotic structural materials (e.g., the SAS electronic package where aluminum is used to replace a magnesium-lithium package). In such cases, the weight of the thermal models has been calculated to simulate the thermal mass of the flight units.

The external configuration of each component has been held as closely as possible to the ATS-A configuration. The units are not intended to be used for mock-up purposes to establish clearance or connector locations on the vehicle. The finishes used on the thermal models have been selected to be representative of the flight hardware.

A "Thermal Interface Information" report (GE Document No. 65SD4421) was prepared by GE for use in the system thermal test. The document contains information relating to the thermal models and includes handling instruction, thermocouple installation locations and a drawing of each unit.

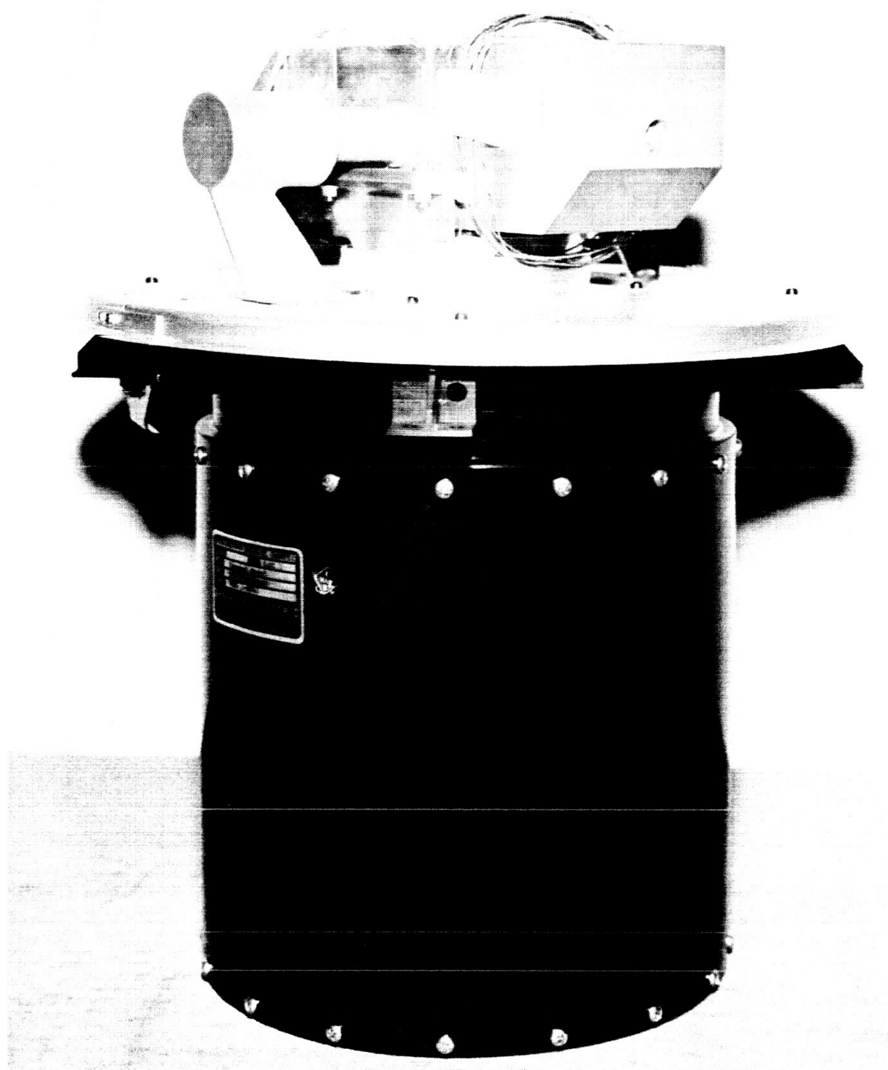

Figure 11-1. CPD with Damper Boom in Stowed Position - Thermal Models

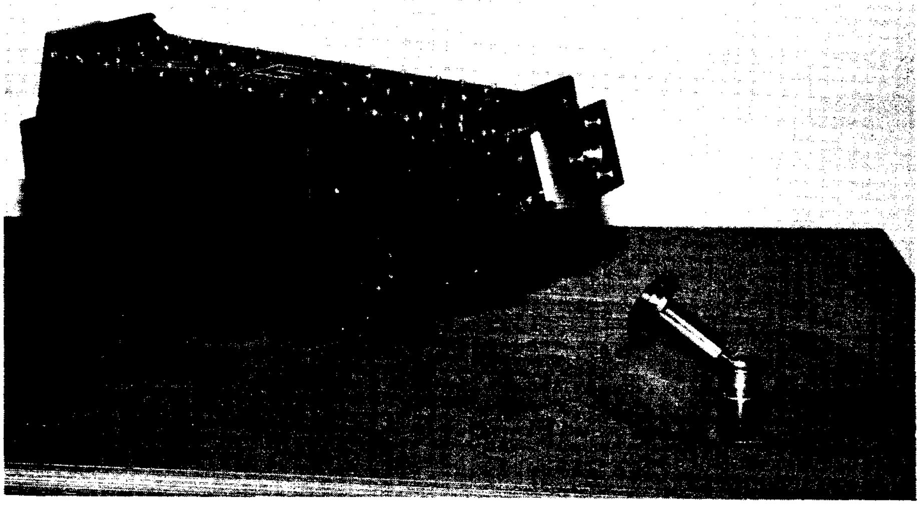

Figure 11-2. Primary Boom Package and TV Target - Thermal Models

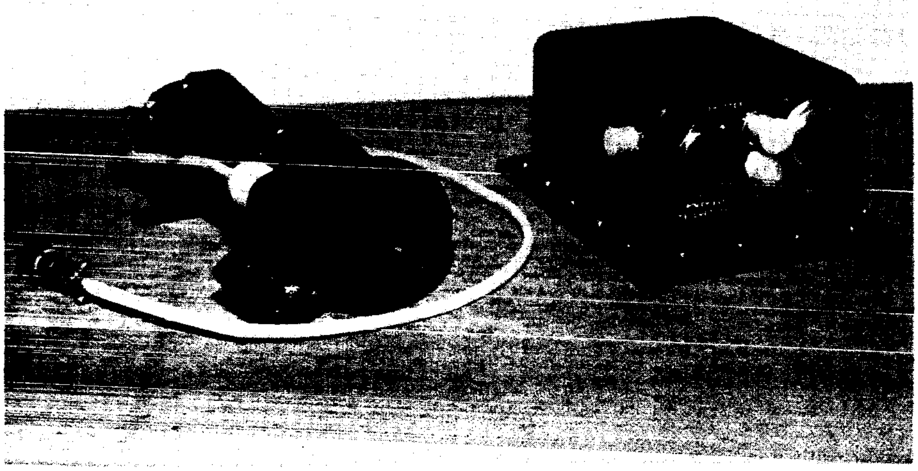

Figure 11-3. TV Camera (left) and Control Unit - Thermal Model

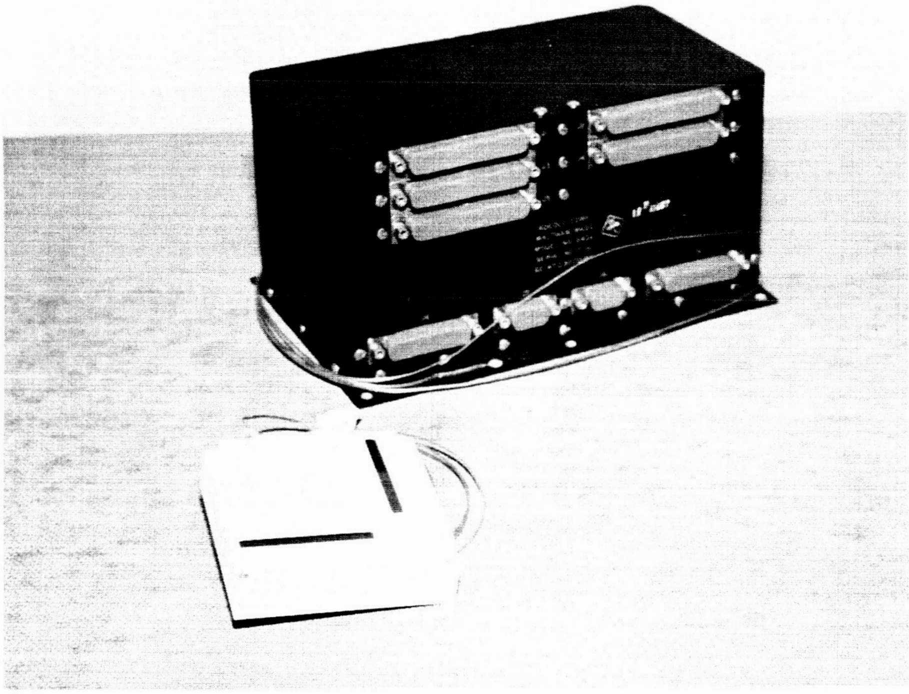

Figure 11-4. Solar Aspect Sensor with Sun Sensor Detector - Thermal Model

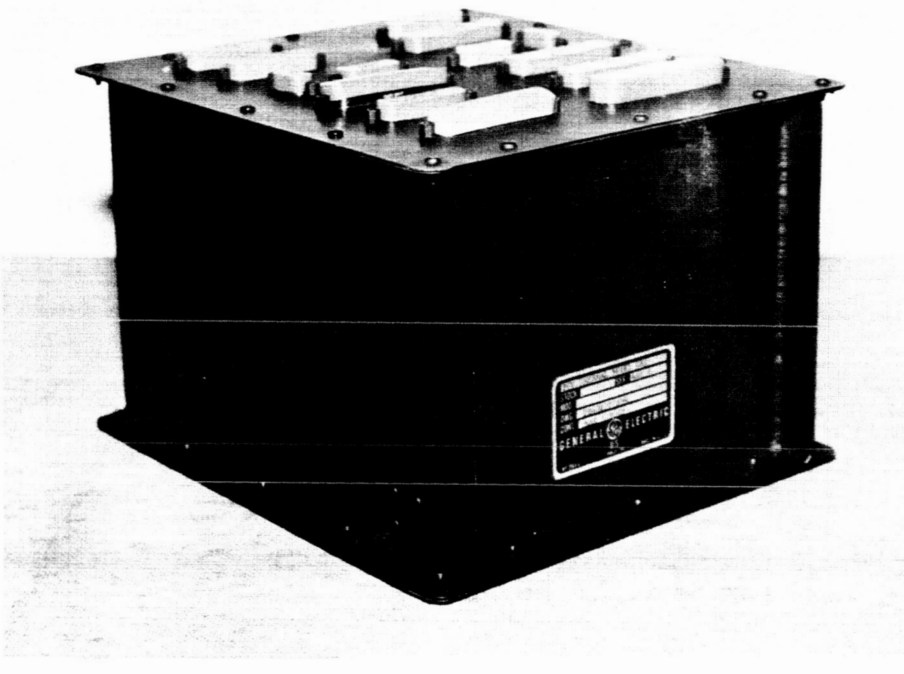

Figure 11-5. Power Control Unit - Thermal Model

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